This is a placeholder page.
The article starts on the following page.

By keeping this page in a PDF document,
you will be able to view this article as 2-page spreads
as they will appear in the printed version of *Home Power*.

Select: View>Page layout>Facing in Adobe Acrobat
to see facing page spreads.

PV Systems

And the 2005 National Electric Code

John Wiles

Sponsored by the Photovoltaic Systems Assistance Center, Sandia National Laboratories

The 2005 *NEC* has been published and will begin to take effect as jurisdictions adopt it, beginning as early as January 2005. Article 690, which covers solar-electric systems, has some changes that will benefit the PV industry by making the code easier to understand, and by allowing modified installation procedures. A few new requirements have also been added. These major changes and new requirements will be covered in here.

Inverter Accessibility

Section 690.14(D) is a new provision in the code that allows utility-interactive inverters to be mounted in areas that are not readily accessible. A readily accessible area is one that can be approached without opening a locked door, removing building materials, or using a ladder or other device to reach the location. For example, utility-interactive inverters may be mounted on the roof of a building near the PV array.

However, DC and AC disconnects must be located at the inverter, and an additional AC disconnect must be located in a readily accessible location as required by 690.14(A) through (C)—usually within easy reach of the ground or floor (6.5 ft; 2 m). These disconnect requirements were covered in *Code Corner* in *HP97* and *HP99.*

Rooftop Conductors

Section 690.31(E) is a new paragraph that permits conductors from a roof-mounted PV array to be run inside the building before reaching the first readily accessible disconnect if those conductors are installed in metallic raceways. Metallic raceways include the various types of metal conduit and metal jacketed, armored cables, like types MC and AC.

Nonmetallic raceways (PVC) are not allowed by this provision because they do not provide the physical protection, fire containment, or ground-fault detection afforded by metallic raceways. Under the 2005 *NEC*, the PV installer can legally hide the conductors, coming from the roof, inside the building without running unsightly conduits down the outside of the structure.

Ungrounded PV Arrays

Section 690.35 was added to permit the use of ungrounded PV arrays in systems where neither of the circuit conductors is grounded, as is currently required for systems operating over 12 volts nominal. This permissive (not mandatory) requirement was added to the code to allow utility-interactive inverters that have no internal or external isolation transformer to be used. Without a transformer, the inverter efficiency will increase while the weight and cost will go down.

The equipment grounding system still must be present, and several other requirements, listed below, will help to ensure that these ungrounded systems are as safe as the grounded systems.

1. Disconnects and overcurrent protection will be required in both of the ungrounded conductors.
2. A ground-fault protection device will be required on all ungrounded PV systems, even when the PV array is not mounted on the roof of dwellings where such a device is currently required.
3. The conductors from the PV array must be installed in raceways (conduit) or be part of a multiconductor sheathed cable. This requirement is to duplicate the protection provided by a double-insulated cable that is not presently available in the United States. Underwriters Laboratories (UL) is developing a new standard for double-insulated cables being designed for use with PV modules. Until these cables are available, the current use of modules with pigtail wiring and Multi-Contact connectors will not be allowed on ungrounded PV arrays.
4. Because many people think that ungrounded PV systems are inherently safer than grounded systems, a warning label will be required at all points where the ungrounded conductors are terminated. Labels with the following warning *Warning: Electric Shock Hazard. The direct current circuit conductors of this photovoltaic power system are ungrounded, but may be energized with respect to ground due to leakage paths and/or ground faults* will have to be attached by the installer at points where the conductors are attached to terminals that may require service, like junction boxes and disconnects.
5. Inverters or charge controllers used in ungrounded systems must be specifically listed for that purpose by Underwriters Laboratories or another acceptable testing and listing agency, such as ETL or CSA.

Installers should note that most of the currently available PV equipment intended for use on 12- to 48-volt PV systems is designed to be used only on grounded PV systems

and would generally not meet the requirements listed above for ungrounded PV systems. Also, most 12- to 48-volt PV systems will continue to use inverters that have transformers.

AC & DC Grounding

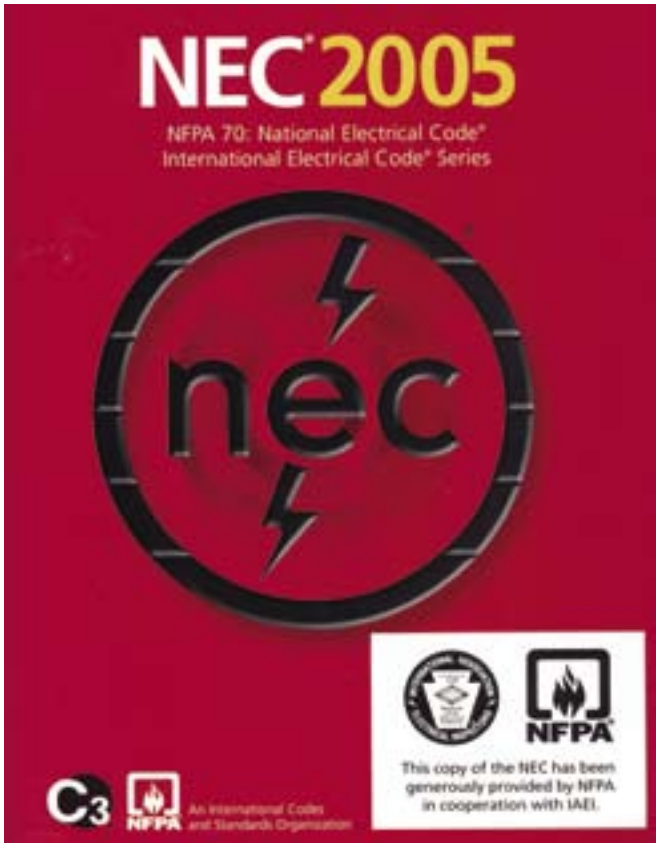
Section 690.47(C) clarifies the requirements for grounding systems that have both AC and DC grounding requirements. Typically, all systems with inverters must have both the AC and the DC sides of the system grounded since the internal transformer in the inverter isolates the DC grounded conductor from the AC grounded conductor. The code allows the DC grounding electrode conductor to be routed to one of two locations:

1. To a DC grounding electrode, which then must be bonded to the AC grounding electrode, or
2. Directly to the AC grounding electrode, where it is connected to that electrode with a separate clamp.

The size of the grounding electrode conductors is determined by sections 250.66 (AC) and 250.166 (DC). The bonding conductor must be sized the larger of the two. See *Code Corners* in *HP102* and *HP103* for additional details on grounding.

Backfed Circuit Breakers

A revision to Section 690.64(B)(5) takes precedence over the code requirement in Section 408.16(F) that all backfed circuit breakers must be clamped to the internal busbar. This revision no longer requires that backfed circuit breakers be clamped to the internal load center busbar if they are connected to a listed utility-interactive inverter, and all circuit breakers in the panel are secured with a front panel.



Diversion Loads

The changes to Section 690.72(B)(2)(2) clarify the requirements of diversion loads in relation to diversion charge controllers.

- The current rating of the load must be equal to or less than the current rating of the controller,
- The voltage rating of the diversion load must be greater than the maximum battery voltage, and
- The diversion load must have a power rating of 150 percent of the power rating of the PV array.

Summary

These are the major changes for the 2005 *NEC*. I encourage all PV system designers and installers to get a copy of the 2005 *NEC* and better yet the 2005 *NEC Handbook*, which has significantly expanded comments on the intent of the code requirements.

The PV Industry Forum has already started formulating proposals for the 2008 *NEC*. These must be finalized before the end of November 2005. Send me your comments and suggestions for the 2008 *NEC* and I will ensure they get the thorough review they deserve.

Access

John C. Wiles, Southwest Technology Development Institute, New Mexico State University, Box 30,001/MSC 3 SOLAR, Las Cruces, NM 88003 • 505-646-6105 • Fax: 505-646-3841 • jwiles@nmsu.edu • www.nmsu.edu/~tdi/

Sponsor: Sandia National Laboratories, Ward Bower, Department 6218, MS 0753, Albuquerque, NM 87185 • 505-844-5206 • Fax: 505-844-6541 • wibower@sandia.gov • www.sandia.gov/pv

The 2005 *NEC* and the *NEC Handbook* are available from the National Fire Protection Association (NFPA), 11 Tracy Dr., Avon, MA 02322 • 800-344-3555 or 508-895-8300 • Fax: 800-593-6372 or 508-895-8301 • custserv@nfpa.org • www.nfpa.org